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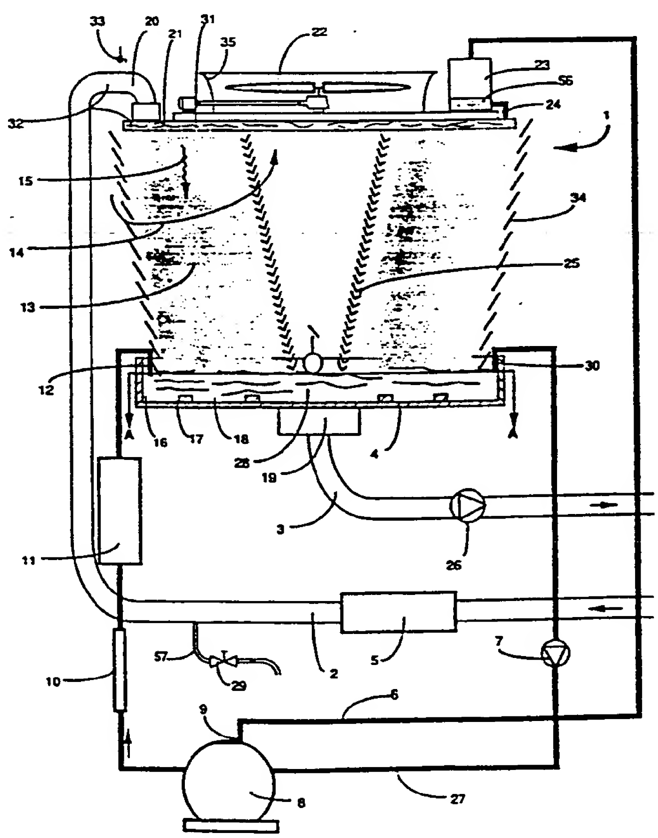
(54) Title: WATER TREATMENT

(57) Abstract

A water treatment device and method for the prevention of dirt, sludge and biomass accumulation, the prevention of detectable microbial activity, and the prevention of scale and corrosion. The invention has a major application in cooling towers (1) for the prevention of Legionnaires' disease. Ultraviolet (UV) light is applied in a novel manner (5) to sterilise the entire cooling tower water volume typically 25 times per hour by treating the entire condenser return pipe (2) water flow. A mechanical cleaning system comprising sweeper arms and supply pickup pipes (not illustrated) continually cleans the tower basin (4) by agitating the water and lifting and removing settled solids. This is driven by a side stream water circuit which also includes a filter (8) and back-flush recovery tank (23), and electromagnetic or electrochemical water treatment device (10) which controls scale and corrosion without water "bleed off" to waste (29).



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WATER TREATMENT

FIELD OF THE INVENTION

This invention relates to an apparatus and non chemical method for the treatment of water, and relates particularly, although not exclusively to water treatment in cooling towers for:

the prevention of dirt accumulation;

the prevention of detectable microbial activity in return condenser water and;

the prevention of scale and corrosion of air conditioning plant cooled by the cooling tower water (otherwise known as condenser water).

DISCUSSION OF THE PRIOR ART

The invention or aspects of the invention have widespread application in, for example, domestic water supplies, fisheries, spas, swimming pools and any industrial or commercial application where algae, bacteria, viruses, or amoeba are undesirable in a water feeding system or supply. The following description will be given with particular reference to cooling towers in building air conditioning plants, however it is to be understood that the invention is not limited to this application.

There is a constant volume of recirculating water in a cooling tower. This is typically 4000 - 40,000 litres which is pumped through "heat generating" refrigeration plant back to the cooling tower which cools the water by some 7°C. The flow rates through the condenser water pipes vary depending on the size of the plant but typically fall within the range of 3-140 litres per second.

The cooling tower is provided with a fill which is a series of wooden or plastic slats through or over which the water trickles to a tower basin. As it trickles to the basin the evaporative effect of air cools the water. This is

amplified by a large fan in the top of the cooling tower which sucks air through the tower fill out the top of the tower.

It is the action of air through the water and the splashing effect of water which causes aerosol droplets to form and it is these droplets which can contain legionella bacteria. The droplets are able to be inhaled and can cause Legionnaire's disease which has a 20-30% mortality rate.

The condenser water is usually close to the ideal temperature range for bacterial growth and total bacterial counts(TBC) of 10^7 colony forming units per millilitre (cfu/ml) are not uncommon. TBC counts do not include legionella bacteria which need to be specifically cultured. Legionella bacteria have been found in large percentages of cooling towers (up to 100% in one study).

Scientists have found high levels of legionella bacteria in cooling towers that are clean and have low numbers of TBC. There is no definitive scientific evidence to support the theory that legionella and TBC levels are inter-related.

The tower basin becomes dirty very quickly due to air borne particulate material which is deposited into the water. Cleaning of cooling towers is particularly difficult as the basin is usually inaccessible due to the close proximity of the tower fill.

The continual evaporation of water from cooling towers causes a buildup of dissolved salts and chemicals conducive to scale formation and corrosion of copper and iron components of air conditioning plant.

Conventional water treatment of cooling towers is by the use of chemicals for scale, corrosion and microbial control. These are applied in conjunction with a monthly inspection programme and manual cleaning as required.

The chemicals used for corrosion control include chromate and phosphanate based compounds. Chemicals used for microbial control include chlorine, quaternary ammonium based compounds, tin butyl oxide compounds, bromine, ozone and chlorine dioxide. Most of these chemicals are toxic and enter the environment either through drift from the cooling tower or bleed off to waste water. A number of the chemicals used for microbial control are oxidising agents and over a period of time cause corrosion and delignification of wooden structures. Some chemicals such as ozone degrade certain plastic materials including fibreglass.

Conventional water treatment of cooling towers relies upon continual dosing of anti-corrosive chemicals to cooling towers via dosing pumps interlocked to the condenser water pump. When the condenser water pump is activated by cooling demand the dosing pump automatically pumps anti-corrosive chemical into the condenser water. Anti-microbial chemicals are similarly added although in many cases they are added monthly on a manual slug dose basis.

The build-up of total dissolved solids and suspended solids previously described is conventionally controlled in part by opening a valve to waste water causing an amount of "bleed off" to occur thus diluting the contaminants. Typically this is 50% of water consumption.

SUMMARY OF THE INVENTION

According to one aspect of the invention there is provided a method of water treatment for a water supply system, the process comprising the steps of:

in-line ultraviolet (UV) light sterilisation of water flowing through the water supply system;

mechanically agitating the water in selected regions of the supply system for lifting settled dirt or biomass in the selected regions; and,

filtering the agitated water to remove suspended dirt or biomass;

whereby, in use, the combined effects of said steps of sterilisation, agitating and filtering can reduce the level of water borne bacteria and algae to negligible levels.

According to another aspect of the present invention there is provided a system of water treatment for a water supply system, the water treatment system comprising:

in-line ultraviolet (UV) light sterilisation means for sterilising water flowing in-line through the water supply system;

mechanical agitating means for mechanically agitating the water in selected regions of the supply system to lift settled dirt or biomass in the selected regions: and,

filtering means for filtering the agitated water to remove suspended dirt or biomass;

whereby, in use, the combined effects of said sterilising, agitating, and filtering can reduce the level of water borne bacteria and algae to negligible levels.

According to a further aspect of the present invention there is provided an ultraviolet (UV) light sterilisation unit for in-line treatment of flowing water, the unit comprising:

a UV light tube for radiating UV light into a region immediately adjacent the tube;

a substantially transparent sleeve assembly for removably housing said UV light tube and adapted to protect the light tube from exposure to water whereby, in use, said sleeve assembly can be immersed in flowing water with the tube therein to provide in-line sterilisation of the flowing water.

According to a still further aspect of the present invention there is provided a mechanical cleaning apparatus for agitating water in a vessel, the apparatus comprising:

a plurality of water inlet pipes extending through the vessel for feeding water under pressure into the vessel;

a plurality of flexible sweeping tubes connected to said inlet pipes and adapted to sweep the vessel in a random snake like motion as water from the inlet pipes is ejected from the ends of the tubes; and,

a plurality of water outlet pipes provided adjacent the sweeping tubes for removing water from the vessel whereby, in use, the motion of the sweeping tubes agitates the water and causes settled material to become suspended in the water for removal via the outlet pipes.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the nature of the invention may be better ascertained preferred embodiments will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of a cooling tower fitted with an embodiment of the invention. The UV steriliser prototype I is depicted;

Figure 2 is a schematic diagram of a cooling tower fitted with a different embodiment of the invention. The UV steriliser prototype II is depicted;

Figure 3 is a plan view of the cooling tower mechanical cleaning system through section A-A of figure 1;

Figure 4 is a close up view of a cooling tower sweeper illustrated in figure 3;

Figure 5 is a side elevation of the UV steriliser prototype I;

Figure 6 is a plan view B-B of the UV steriliser prototype I illustrated in figure 5;

Figure 7 is a plan view of an O-ring type UV tube holder along B-B;

Figure 8 is a sectional view of the UV steriliser prototype I along C-C of figure 6;

Figure 9 is an enlarged view of area A of figure 8; and,

Figure 10 is a side elevation of a removable UV tube holder; and,

Figure 11 is a sectional view of the UV steriliser prototype II in a modular configuration; and,

Figure 12 is a sectional view of the UV steriliser prototype II in a unitary configuration; and,

Figure 13 is a plan view of the access hatch 102 in figures 12 and 13; and,

Figure 14 is a end view along E-E in figure 11 of the UV tube assembly; and,

Figure 15 is a sectional view of a UV tube assembly along F-F in figure 14; and,

Figure 16 is an enlarged view of area B of the UV tube assembly in figure 15.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to figure 1, cooling tower water 28 is drawn through the cooling tower sump 19 into the condenser supply pipe 3 through the condenser pump 26. It returns via the condenser return pipe 2. In small systems with up to 12 Ls^{-1} condenser pump flow rate, the UV steriliser prototype I 5 is installed in the condenser return pipe 2 and the entire condenser water flow is sterilised to a 99.9% kill efficiency per passage of water.

The water in the condenser return pipe 2 enters the top of the cooling tower 1 via the condenser pipe outlet 20 into header boxes 21. Header boxes 21 are covered (not illustrated) to prevent light entering and promoting algal growth, a known risk factor for legionella growth. The return condenser water 32 is sterilised to the extent that viable bacteria are not

detectable using standard analysis of 50-100 microlitres of condenser return water taken from sampling cock 33. The advantage of this is that there is no possibility of legionella becoming airborne and causing Legionnaires' disease as all bacteria are previously removed from the source which is recirculated condenser water.

The return condenser water 32 passes through distributor holes 31 into the tower fill 13 in a downward path 15 back to the tower basin 4 to repeat the cycle. The cooling tower fan 22 sucks air 14 through the tower side slats 34 through the tower fill 13 out through the fan cowling 35. The aerosols thus generated are safe by virtue of the sterile nature of the return condenser water 32.

Cooling tower and condenser water are part of the same body of recirculating water which is filtered to a minimum 10 micron cutoff by a sand filter 8 thus removing suspended solids. Cooling tower mechanical cleaner supply water 30 passes to supply the side stream circuit pump 7. It then passes through the sand filter 8 to a magnetic or electrochemical corrosion and scale treatment unit 10, to an optional second UV steriliser prototype I 11 to the cooling tower mechanical cleaner return water 12. The optional second UV steriliser prototype I 11 is a fail-safe backup device to the first UV steriliser prototype I 5.

The magnetic or electrochemical water corrosion and scale treatment unit 10 is a proprietary device which causes scale forming ions to crystalise from solution as filterable colloids and which also claim to generate free electrons into the water. These prevent corrosion by mimicking the preferential supply of electrons to corrosive reactions by cathodic protection techniques. These technologies are well known to experts in the field.

The sand filter 8 contains an automatic back-flush system 9 (not illustrated in detail) commonly in use in other applications. Backflush water is directed via the back-flush

pipe 6 to a back-flush water recovery tank 23 mounted on top of the cooling tower 1.

The back-flush water passes through a graded sand bed 56 in the base of the back-flush water recovery tank 23 and gravity feeds back to the cooling tower via the recovery tank outlet pipe 24 thus conserving water. The suspended solids are retained on or in the sand bed 56 for periodic manual removal approximately every six months.

The bleed-off pipe 57 leads to the bleed-off valve 29 to waste. The bleed-off valve 29 is closed compared to conventional chemical water treatments which permit approximately 50% of water consumption to "bleed" to waste.

Drift eliminators 25 are not required to be relied on to prevent legionella drift because of the insignificant risk of legionella bacteria being present in drift.

A second alternative plumbing arrangement is illustrated in figure 2 whereby the side stream circuit pump 7 is eliminated. Supply suction is obtained from the condenser pump 26 by taking cooling tower mechanical cleaner supply water 30 by suction at point 36 situated on the supply side of the condenser pump 26. The sand filter 8 is supplied by water under pressure taken from the condenser supply pipe at point 37 after the condenser pump 26. The flow rate of the side stream circuit is 3-12 Ls^{-1} depending on the size of the cooling tower 1.

The UV steriliser prototype II 101 contains UV tube assemblies 38 which are inserted into condenser return pipe 2 in systems with condenser flow rates greater than approximately 12 Ls^{-1}, thus achieving similar sterilisation specifications as in the abovementioned example of the UV steriliser prototype I. The UV tube assemblies 38 permit sufficient amounts of UV light to be radiated in a cost efficient manner to sterilise the entire condenser water flow. Because they utilise existing pipework they are also space efficient which is an important commercial and physical consideration for many buildings.

The cooling tower mechanical cleaning system 50 depicted in detail in figure 3 is designed for a very large tower and contains two cells within the tower separated by a cell dividing wall 47. Each cell is cleaned at separate times by timer controlled solenoids 39. The cooling tower mechanical cleaning return water 12 is via primary feeder lines 41 which feed to secondary feeder lines 42. The primary and secondary feeder lines are suspended approximately 20 cm from the bottom of the tower basin 4 by supports and nylon ties (not illustrated). Water passes to the cleaning sweepers 45 which agitate and mechanically scrape the wetted surfaces of the tower basin 4 suspending settled dirt and biological growth which may be loosely settled or adhered.

The suspended material enters the supply pickup pipes 46 suspended approximately 5 centimetres below the water in the tower basin 4 so as not to impede the cleaning sweepers 45. The supply pickup pipes 46 are in the immediate area of the suspended material which then enters into secondary supply lines 48 and primary supply lines 44. The solids suspended in water supply the side stream circuit pump 7 and the sand filter 8 where suspended solids are removed from circulation.

Variable gate valves 40 and 43 provide means to adjust the flow rates through the return and supply circuits to ensure optimum performance of the cleaning sweepers 45 and the optimum amount of supply water to the side stream circuit pump 7.

The cleaner sweepers 45 are illustrated in some detail in figure 4 and comprise a piece of plastic tube 51 which is approximately 12 mm outside diameter and 1 metre long. It is typically fitted with 6 interference fit nylon slider weights 52 fastened firmly to the plastic tube 51. These nylon slider weights 52 permit minimal friction with the adjacent surface via a raised edge 53. They also weight the cleaner sweeper at the end and thus keep the end nozzle 54 under water. The end nozzle 54 contains a small orifice 55 which projects a forceful

stream of water thus propelling the cleaner sweeper in a random snake like motion and cleaning the tower basin 4.

The cleaner sweepers 45 and the supply pickup pipes 46 are located and designed so as to avoid the cleaner sweepers 45 being hindered or impeded by obstructions in the tower basin 4. Long flexible pipe-like probes are inserted across the basin floor prior to installation and obstacles such as structural beams are mapped. A design plan tailored to that tower is devised so that in operation the cleaner sweepers 45 have an unimpeded sweep path and are not likely to become intractably caught upon such obstacles or in corners.

The cooling tower mechanical cleaning system ensures that no pockets of dirt or sludge are left in corners 16, 17 or inaccessible still spots 18 of the tower basin 4. A minimum clearance rate of 0.3 kg $m^{-2}hr^{-1}$ of mixed sand and clay type soil (50:50) is achievable over the entire tower basin surface to absolute removal. This rate is generally sufficient to cope with dirt, sludge accumulating in a cooling tower but the clearance rate can be increased, if necessary, by increasing the flow rate through the cooling tower cleaning system and/or increasing the number of cleaner sweepers 45 and supply pickup pipes 46.

Referring now to figures 5,6,7,8 and 9 the UV steriliser prototype I comprises a water treatment vessel 58 with removable end plates 81 all made of marine grade aluminium, stainless steel, UV resistant fibreglass or some other UV resistant plastic. The end plates 81 are attached to the water treatment vessel 58 by flanged connections joined by some 20 bolts and nuts 69 located evenly around the flange 78.

The end plates 81 have a variable number (between 1-6) of O-ring type UV tube holders 70 or of removeable seal type UV tube holders 107 mounted to secure the glass sleeves 62 containing the UV tubes 90. The glass sleeves 62 are laminated with a thin layer of UV transparent fluorinated ethylene propylene known as TEFLON™ by the DUPONT Company. TEFLON™has

unique properties in that it is UV light stable, transmits UV well and has well known non-stick properties. This maximises UV light transmission by reducing dirt and biofilm accumulation on the surface of the glass sleeve 62.

The electrodes of the UV tubes 63 are connected by standard electrical connections 71 to a power source(not illustrated). A cover 73 fits over the end plates 81 to conceal the electrical connections 71.

The water outlet pipe 109 contains a flange fitting 68 and also has a sampling cock 67 fitted for testing the sterility of the outlet water. The water treatment vessel 58 contains a removeable access hatch 65 for maintenance and inspection purposes which is secured by wing nuts 66 for easy operation. It is sealed by an O-ring (not illustrated) to the water treatment vessel 58.

Referring to figure 8, inlet water passes through the inlet flange 59 through inlet pipe 110, through a sieve screen 85, through a conical venturi 86 into the inlet end of the water treatment vessel 58. Water and impaction beads 83 are sucked into the region of the venturi effect 84. These impaction beads 83 are approximately 12 mm diameter plastic core, coated with a UV reflective substance such as aluminised paint. They do not substantially diminish the intensity of UV light in the the water treatment vessel 58.

The water and the impaction beads pass through a diffuser screen 80 which ensures that the water is not channeled unevenly through the water treatment vessel 58. The impaction beads randomly impact upon the glass sleeves 62 and have a cleaning effect. They pass towards the water outlet until they are deflected by a deflector sieve 87 through an impaction bead feeder line outlet 79 into an impaction bead feeder line 82 to the zone of the venturi effect 84 in the inlet pipe 110.

The water passes through the deflector sieve 87 to the outlet pipe 109 and is exposed to sufficient UV light to render

a 99.9% kill to all of the bacterial types present. Bacteria are not detectable by standard dipslide or agar plating methods.

Area A in figure 9 illustrates the O-ring type UV tube holder 70 which comprises a round plate with a central hole for the glass sleeve 62 to pass through. The O-ring UV tube holder 70 is secured to the end plate 81 by bolts 94 and nuts 95. The edge of the O-ring type UV tube holder adjacent the end plate 81 is chamfered 108 to accommodate an O-ring 93. This O-ring is compressed against the glass sleeve 62 and the end plate 81 to create a water tight seal.

The UV tube 90 is located inside the outer glass sleeve 62 and is separated by a air space 91. The end of the UV tube contains a insulated end cap 111 from which projects an electrode 63 which provides current to an filament 92.

In an alternative embodiment of the invention the outer quartz glass sleeve 62 is absent so that UV tubes are directly in contact with water.

The removable seal type UV tube holder 107 illustrated in figure 10 is the preferred type as it is easily replaceable in the end plates 81 with threaded plugs. Thus the number of UV tubes can be easily increased or decreased according to the flow rate of treated water and the water quality.

A standard hydraulic seal 98 is activated by the water pressure inside the water treatment vessel 58 and seals in a watertight manner against the outer face of the outer glass sleeve 62 and against the seating faces 105 and 106 in the main body 99 of the removable seal type UV tube holder 107. When the water pressure is released inside the water treatment vessel 58 the hydraulic seal 98 releases and the outer glass sleeve 62 is easily slid from the removable seal type UV tube holders for maintenance and/ or replacement.

A threaded area 100 screws into the end plates 81 to provide a watertight seal between the gasket 76 and the end plate 81. A hexagon shaped area 75 is provided for tightening and loosening using standard spanners. A second threaded area 77 allows a cover 89 to be screwed into place thus locating the outer glass sleeve 62 and the UV tube (not illustrated) contained within the outer glass sleeve. A standard type spring loaded electrical terminal (not illustrated) is fixed to the cover 89 and allows a tolerance of some 5mm in the exact location and length of the UV tube (not illustrated).

The UV steriliser prototype II 101 is a modular embodiment designed to sterilise large flow rates of condenser water. Referring to figures 11, 12, 13, 14, 15 and 16 the device comprises a length of condenser water pipe 122 of variable width with UV tubes inside glass sleeves 123 arranged in UV tube assemblies 38 which can be inserted into existing condenser water pipes 122 to sterilise the entire condenser water flow. The advantages are that the UV tube assemblies can contain 1 or more UV tubes inside glass sleeves 123 depending on the condenser pipe size and water flow rate. Additional modules are easily inserted into the condenser water pipe to cope with various flow rates and water quality.

Access panels 102 are installed onto existing condenser water pipes 122. They are removable by wing nuts 121 which act to force the access panel against an O-ring seal (not illustrated) in a machined groove on the underside of the access panel 102 thereby sealing the condenser water inside the condenser pipe 122. The access panels 102 are of sufficient size so as to permit the installation of UV tube assemblies 38 inside the condenser water pipe 122.

The UV tube assembly 38 illustrated in figures 15 and 16 comprises two plastic mouldings 128 made of a suitable plastic material. This is preferably of high tensile strength, UV stable, machinable and a good electrical insulator. The plastic mouldings incorporate proprietary hydraulic gland seals 129 in the tube holding yoke 127 of the plastic moulding 128.

During assembly the UV tube inside a glass sleeve 123 is glued into a hole at adhesive bond 130 securing the UV tube inside glass sleeve 123 to the tube holding yoke 127. The adhesive used is silicone based or some other similar material which has good resistance to UV light and good adhesion to glass. The hydraulic seal 129 is then slid over the UV tube inside a glass sleeve 123 into its working location as illustrated.

Thus the spring loaded electrical connection 135 joining the UV tube electrode 131 to the electrical wire 132 is double insulated from the condenser water via an adhesive bond 130 and a hydraulic seal 129. The insulated electrical wire 132 to terminal 133 provides a double insulated effect.

A hole in the condenser water pipe accommodates the fastening lug 120 of the mounting arm 124 of the UV tube assembly. The fastening lug 120 is sealed against the condenser water pipe 122 using a rubber washer or O-ring (not illustrated) and a nut 125 secures the fastening lug 120 firmly to the condenser water pipe 122.

A bead impaction system is used in the UV steriliser prototype II which is similar to that employed in the UV steriliser prototype I. It is used to clean the glass sleeves containing the UV tubes 123. The various components of this cleaning system are:

impaction beads 134 ;

a venturi device 113 operating which creates a low pressure venturi zone when water passes over the venturi device 113 in the direction 104 indicated;

a sieve 114 which allows water passage but prevents impaction beads 134 from drifting past when the condenser water is not being pumped;

a sieve 115 which allows water passage but directs impaction beads 134 to the impaction bead feeder line outlet 116.

The unitary embodiment of the UV steriliser prototype II 118 whereby the modular UV tube assemblies 38 are modified to allow them to be connectible and inserted as one unit in a condenser water pipe 122 involves technology similar to that applied in the first modular embodiment 101 of the UV steriliser prototype I 101 and the details of the seals and connecting methods are not illustrated. The advantages are that fewer electrical connections are required.

A further modification to the UV steriliser prototype II is the shaping of the plastic mouldings 128 in a manner designed to minimise disruption to the laminar flow of the condenser water by incorporating a bulbous shape at the points of initial water contact tapering away to allow smooth water flow.

The UV steriliser prototypes I and II have a number of design aspects which enhance the efficiency of the devices. For example, were a single high efficiency UV tube to be located centrally in the UV steriliser prototype I, over five times the minimum lethal dose of UV light to kill legionella bacteria at a flow rate of $12.6Ls^{-1}$ would be delivered.

The units achieve sterilisation of water by:

creating sufficient dosage of UV light to kill all types of bacteria found in cooling towers;

ensuring that this dosage is delivered consistently in the most demanding of conditions experienced in cooling towers to the total condenser flow rate. This flow rate is substantial and typically ensures that in normal operation that the entire cooling tower 1 and condenser water volume is sterilised approximately 10 times per hour during operation.

A lethal dose of UV light can be continuously delivered by the UV sterilisers 101, 5 and 11 by:

proper design of the water treatment vessel 58 and condenser pipe installations to ensure that the flow rate of water through UV light is sufficiently slow to allow sufficient exposure to UV light;

the condenser and cooling tower water 28 is continuously filtered by sand filter 8 to remove suspended solids and colloids which promote scale and corrosion formation in air conditioning plant and on proprietary electromagnetic and electrochemical water treatment devices and fouling of the glass tubes 62;

settled and adhered biomass and scale is mechanically removed from the cooling tower 1 to minimise fouling of air conditioning plant and tower basin 4;

a proprietary magnetic or electrochemical water corrosion and scale treatment unit 10 crystalises scale forming dissolved solids from the condenser and cooling tower water 28 and prevents the deposition of scale onto the glass sleeves 62 and air conditioning plant. These dissolved solids are deleterious in that they decrease UV light transmittance and promote fouling of the glass sleeves 62 containing the UV tube 90;

a thin layer of TEFLON™ or some other similar material which allows a high level of UV light transmittance is applied to the outer surface of the glass sleeve 62 in contact with water. This has self-cleaning and non adhesive properties which minimise fouling and scaling normally associated with silica containing glass sleeves 62. Silica is one of the elements which act as a binder for scale deposition.

An automated cleaning device comprises small plastic impaction beads which are recycled through the UV water treatment vessel and which randomly impact upon the glass sleeves 62 thus providing a mild abrasive cleaning action. This is incorporated in the water treatment vessel 58 and condenser pipe 122 to continually clean the surfaces of the glass sleeves 62.

The various aspects of the invention may be interrelated and when combined result in:

undetectable levels of water borne bacteria using standard analytical techniques;

cooling towers and the condenser water contained therein are constantly in a very clean state without the need for manual cleaning;

scale and corrcsion of air conditioning plant are eliminated;

significant water savings are achieved by eliminating water normally "bled off" to waste; and,

no chemicals are used thus the process is environmentally friendly.

The result of the combined action of the various aspects of the invention provides a chemical free water treatment system for cooling towers which does not rely upon chemicals being added; does not rely upon water bleed off to waste; does not rely upon manual cleaning; and provides efficient scale and corrosion control and; provides bacterial control to undetectable levels of bacteria in condenser water outlet.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS

1. A method of water treatment for a water supply system, the process comprising the steps of:

in-line ultraviolet (UV) light sterilisation of water flowing through the water supply system;

mechanically agitating the water in selected regions of the supply system for lifting settled dirt or biomass in the selected regions; and,

filtering the agitated water to remove suspended dirt or biomass;

whereby, in use, the combined effects of said steps of sterilisation, agitating and filtering can reduce the level of water-borne bacteria and algae to negligible levels.

2. A method as defined in claim 1 which further comprises the treatment of water flowing through said water supply system with electromagnetic or electrochemical devices which crystalise scale forming dissolved solids into suspended solids for removal by said filtration thereby controlling scale and corrosion without the use of "bleed off" water to waste.

3. A method as defined in claim 1, wherein said step of ultraviolet light sterilisation means UV sterilisation of the entire condenser water flow volume of cooling towers and is at lower ranges of condenser flow rates to suit small to medium air conditioning plant and requires the installation of a water treatment vessel in to the condenser pipe thereby sterilising the entire condenser water flow to negligible levels of bacteria not detectable by standard methods, the condenser flow being typically such that the entire condenser/cooling tower water volume is circulated approximately twenty five times per hour thereby providing an extremely efficient and safe sterilisation process.

4. A method as defined in claim 1, wherein said step of ultraviolet light sterilisation means UV sterilisation of the entire condenser water flow volume of cooling towers and is at the upper ranges of condenser flow rates to suit medium to large air conditioning plant and requires the installation of

UV tubes to be assembled into modules and inserted into existing condenser pipes thereby sterilising the entire condenser water flow to negligible levels of bacteria not detectable by standard methods, the condenser flow being typically such that the entire condenser water volume is circulated approximately twenty five times per hour thereby providing an extremely efficient and safe sterilisation process.

5. A method as defined in claim 1, wherein said step of mechanically agitating the water in selected regions of the supply system for lifting settled dirt or biomass further comprises the automated mechanical removal of adhered and non adhered dirt, sludge and biomass from a cooling tower basin on a daily or continual basis.

6. A method as defined in claim 5 wherein said automated mechanical removal further comprises;

the incorporation of a water powered mechanical cleaning system in to a side-stream filtration circuit to utilise the existing water power;

directing the return water through a grid of pipes suspended above the cooling tower basin to outlets provided across the entire basin floor;

plastic flexible hoses attached to said outlets distribute the water in a forceful manner in a random snake like trajectory;

adhered and non adhered dirt, sludge and biomass is removed from all pockets, obstructions and corners of the basin by the forceful water pressure and by the mild abrasion of the said moving plastic hoses;

said dirt, sludge and biomass is suspended in water and the suspension is removed by supply pickup pipes suspended strategically just below the water level around the basin;

said supply pickup pipes feed the suspension to said filter where the suspended solids are removed.

7. A method as defined in claim 1, wherein said step of fine filtration of suspended solids and colloids means from condenser water of cooling towers and further comprises;

the removal of a side-stream of water from the cooling tower basin through a stand alone pump or an existing condenser pump, and to a sand filter back into the tower basin;

the waste water from the automatic or timer controlled back-flushing of the filter is directed to a gravity fed recovery tank on top of the cooling tower;

said gravity fed recovery tank contains a sand bed in the base through which said waste water is filtered and recovered;

said sand bed is periodically replaced or cleaned.

8. A method as defined in claim 2, wherein said step of electromagnetic or electrochemical treatment of cooling tower/condenser water volume further comprises:

the installation of said proprietary device in to said side stream water circuit;

the water passing through becomes treated and dissolved solids which normally cause scale, precipitate to form colloidal crystals and solids;

the colloidal crystals and solids thus generated are suspended in the water and some are filtered by said filtering method whilst others settle in the tower basin where they are removed by said mechanical agitation and filtration without the need for water to be bled to waste.

9. A system of water treatment for a water supply system, the water treatment system comprising:

in-line ultraviolet (UV) light sterilisation means for sterilising water flowing in-line through the water supply system;

mechanical agitating means for mechanically agitating the water in selected regions of the supply system to lift settled dirt or biomass in the selected regions; and,

filtering means for filtering the agitated water to remove suspended dirt or biomass;

whereby, in use, the combined effects of said sterilising, agitating, and filtering can reduce the level of water borne bacteria and algae to negligible levels.

10. A system as defined in claim 9 further comprising; an electromagnetic or electrochemical water treatment device means for converting dissolved solids which cause scale to suspended solids for removal by said filtering.

11. A system as defined in claim 9, wherein said ultraviolet light sterilisation means sterilisation of the entire condenser water flow volume found in the lower ranges of condenser flow rates to suit small to medium air conditioning plant whereby:

a UV light water treatment vessel is installed in to the condenser pipe circuit thereby sterilising the entire condenser water flow to negligible levels of bacteria not detectable by standard methods;

the entire condenser and cooling tower water volume is sterilised typically twenty five times per hour depending on the installation.

12. A system as defined in claim 9, wherein said ultraviolet light sterilisation means sterilisation of the entire condenser water flow volume in the upper ranges of condenser flow rates to suit medium to large air conditioning plant whereby:

UV tubes are assembled into modules and inserted into existing condenser water pipes thereby sterilising the entire condenser water flow to negligible levels of bacteria not detectable by standard methods;

the entire condenser and cooling tower water volume is sterilised typically twenty five times per hour depending on the installation.

13. A process as defined in claims 11 or 12 wherein said step of ultra violet light sterilisation of water further comprises:

the cleaning of dirt and sludge from the water system by means of a mechanical cleaner to clean the cooling tower basin;

the water is then passed through a side stream filter to remove the suspended solids thereby enhancing the UV light penetration and disinfection.

14. A process as defined in claims 11 or 12 wherein said step of ultra violet light sterilisation of water further comprises:

an electromagnetic or electrochemical scale and corrosion water treatment device is installed in a side stream water circuit;

as water passes through said electromagnetic or electrochemical water treatment unit the water is treated to remove total dissolved solids from solution and to limit the fouling capacity of the water on the UV tubes and glass sleeves;

the water passes through the UV light steriliser and UV light is permitted to be transmitted at a high germicidal intensity due to the decreased dissolved solids and the decreased fouling and scale on the UV tubes.

15. An ultraviolet (UV) light sterilisation unit for in-line treatment of flowing water, the unit comprising:

a UV light tube for radiating UV light into a region immediately adjacent the tube;

a substantially transparent sleeve assembly for removably housing said UV light tube and adapted to protect the light tube from exposure to water whereby, in use, said sleeve assembly can be immersed in flowing water with the tube therein to provide in-line sterilisation of the flowing water.

16. An apparatus as defined in claim 15 wherein said UV light sterilising device further comprises a cylindrical water vessel of large diameter to ensure sufficient exposure to UV light to kill water borne bacteria.

17. An apparatus as defined in claim 16 wherein said cylindrical water vessel further comprises a flanged inlet and outlet on opposite sides and at opposite ends of the vessel.

18. An apparatus as defined in claim 17 wherein said cylindrical water vessel further comprises flanges at both ends and is fitted with end plates secured by bolts to the water treatment vessel with an O-ring sealing the two surfaces together.

19. An apparatus as defined in claim 18 wherein said end plates are fitted with a number of O-ring type UV tube holders depending on the water flow rate and condition.

20. An apparatus as defined in claim 19 wherein said O-ring type UV tube holders are bolted to a hole in said end plate containing a glass sleeve and the action of tightening said O-ring type UV tube holder to said end plate compresses and seals said O-ring against said end plate and said O-ring type UV tube holder thereby providing a glass tube passage through said water treatment vessel.

21. An apparatus as defined in claim 20 wherein said glass tube contains a UV tube which is slid inside said glass tube and is easily removeable for service.

22. An apparatus as defined in claim 21 wherein said glass tube can further comprise said glass tube coated with a thin layer of UV light transparent TEFLON™ which assists in keeping said glass tube clean.

23. An apparatus as defined in claim 20 wherein said end plate means further comprises one or more threaded holes containing removeable seal type UV tube holders, the number depending on the water flow rate and water condition.

24. An apparatus as defined in claim 23 wherein said removeable seal type UV tube holder means further comprises:

a main body;

an upper threaded area for cover attachment;

a lower threaded area and gasket for attachment to said end plate;

a seal retaining recess to accommodate a hydraulic seal;

25. An apparatus as defined in claim 24 wherein said main body further comprises a central hexagon shaped surface for fitting of a spanner for tightening purposes.

26. An apparatus as defined in claim 24 wherein said cover attachment screws onto said main body thereby locating said glass tube and UV tube and also excluding dust and providing an enclosure for the UV tube electrical connections.

27. An apparatus as defined in claim 24 wherein said hydraulic seal further comprises a seal which is activated by the internal water pressure within said water vessel and which in the absence of such pressure the easy withdrawal of said glass sleeve is facilitated for easy maintenance.

28. An apparatus as defined in claim 15 wherein said UV light sterilising device further comprises UV tubes and glass sleeves mounted in cylindrical shaped modular UV tube assemblies which can be inserted inside a condenser pipe through access panels.

29. An apparatus as defined in claim 27 wherein said modular UV tube assembly further comprises two plastic mouldings comprising;

a UV tube or glass sleeve holding yoke;

a mounting arm, fastening lug and nut;

an electrical connection, wire and terminal;

30. An apparatus as defined in claim 29 wherein said holding yoke is a thick circular disc of plastic with number of round apertures for location of the ends of said UV tubes and glass sleeves and hydraulic seals during assembly.

31. An apparatus as defined in claim 30 wherein during assembly;

said glass sleeves are fitted with a hydraulic seal around the glass face and glued into said round aperture of said holding yoke;

said hydraulic seal is slid down said glass tube to the yoke where it rests in a recess in the yoke and is activated by water pressure to seal said yoke and said glass tube;

thus, in use, a double insulated seal is effected between said glass sleeve in contact with the water and the electrical connection.

32. An apparatus as defined in claim 29 wherein said mounting arm is part of the plastic moulding and protrudes out from the yoke to provide at its end point said mounting lug which passes through the condenser pipe and is fastened tight against a gasket by said fastening nut.

33. An apparatus as defined in claim 29 wherein said electrical components further comprise:

said electrical connections are located in said mounting yoke and form a spring loaded connection with said UV tube:

said electrical wire is moulded inside said plastic moulding and connects to a terminal mounted also in the plastic moulding and projecting from the fastening lug and being insulated from the condenser pipe.

34. An apparatus as defined in claim 28 wherein said UV tube assemblies are joined as one unit as they are inserted into the condenser water pipe in order that only two electrical connections are necessary to operate numerous UV tubes over several UV tube lengths of condenser pipe.

35. An apparatus as defined in claim 9 wherein said filter further comprises:

a side-stream water circuit from and returning to the cooling tower basin via a sand filter;

a motor and pump in said side stream circuit or;

said side stream circuit to be driven by the condenser water pump by using a small amount of its capacity;

an automatic pressure or timer operated back-flush valve;

a back-flush pipe to carry back-flush waste water to a recovery tank on top of the cooling tower.

36. An apparatus as defined in claim 35 wherein said recovery tank further comprises;

a graded sand bed in the base of the tank through which waste water filters by gravity to be cleaned;

a water outlet pipe in the base of said recovery tank through which said cleaned waste water is recycled to the cooling tower thus conserving water.

37. A mechanical cleaning apparatus for agitating water in a vessel, the apparatus comprising:

a plurality of water inlet pipes extending through the vessel for feeding water under pressure into the vessel;

a plurality of flexible sweeping tubes connected to said inlet pipes and adapted to sweep the vessel in a random snake like motion as water from the inlet pipes is ejected from the ends of the tubes; and,

a plurality of water outlet pipes provided adjacent the sweeping tubes for removing water from the vessel whereby, in use, the motion of the sweeping tubes agitates the water and causes settled material to become suspended in the water for removal via the outlet pipes.

38. An apparatus as defined in claim 37 wherein said mechanical cleaning apparatus further comprises:

attachment of said mechanical cleaning system to said side stream filtration system incorporating a back-flush recovery system;

a series of primary and secondary feeder lines installed at strategic places throughout the tower basin to deliver water under pressure to said cleaning sweepers;

said cleaning sweepers are placed so as to move about in a random pattern without becoming irretrievably stuck against or entangled in obstructions such as primary and secondary feeder

line supports, tower braces, tower fill and other objects normally found;

supply pickup lines are also distributed throughout the tower to allow dirt, biomass and other solids suspended by the cleaning sweepers to be removed to said side stream filtration;

a series of solenoids and valves to permit control of the water pressure and distribution to enable all sections of the tower to be cleaned daily.

39. An apparatus as defined in claim 38 wherein said cleaning sweepers means further comprises:

a short length of flexible plastic approximately 12 millimetre outside diameter;

a series of plastic slider weights fixed at short intervals along said plastic hose to weigh said hose down underneath the water and to permit easy sliding movement across the tower basin without abrading said plastic hose;

an end nozzle to cause a high pressure stream of water to be emitted which causes removal of dirt, sludge and biomass from the tower basin and causes said material to be suspended in the water for removal.

40. An apparatus as defined in claim 38 wherein said solenoids and valves means further comprises:

adjustable gate valves to alter the water delivery and return through the cleaning sweepers and supply pickup lines to ensure optimum performance of the system;

in large towers timer controlled solenoid valves divert said side stream of water to different cells of the tower thus ensuring that sufficient water pressure and volume is present to clean each area of the tower.

41. An apparatus as defined in claim 10 wherein said proprietary electromagnetic or electrochemical water treatment device is situated within said side stream and:

prevents fouling and scaling of said UV tubes and glass sleeves and air conditioning plant;

precipitates or crystalises dissolved solids into suspended crystals or solids for removal by said mechanical cleaner and filter system.

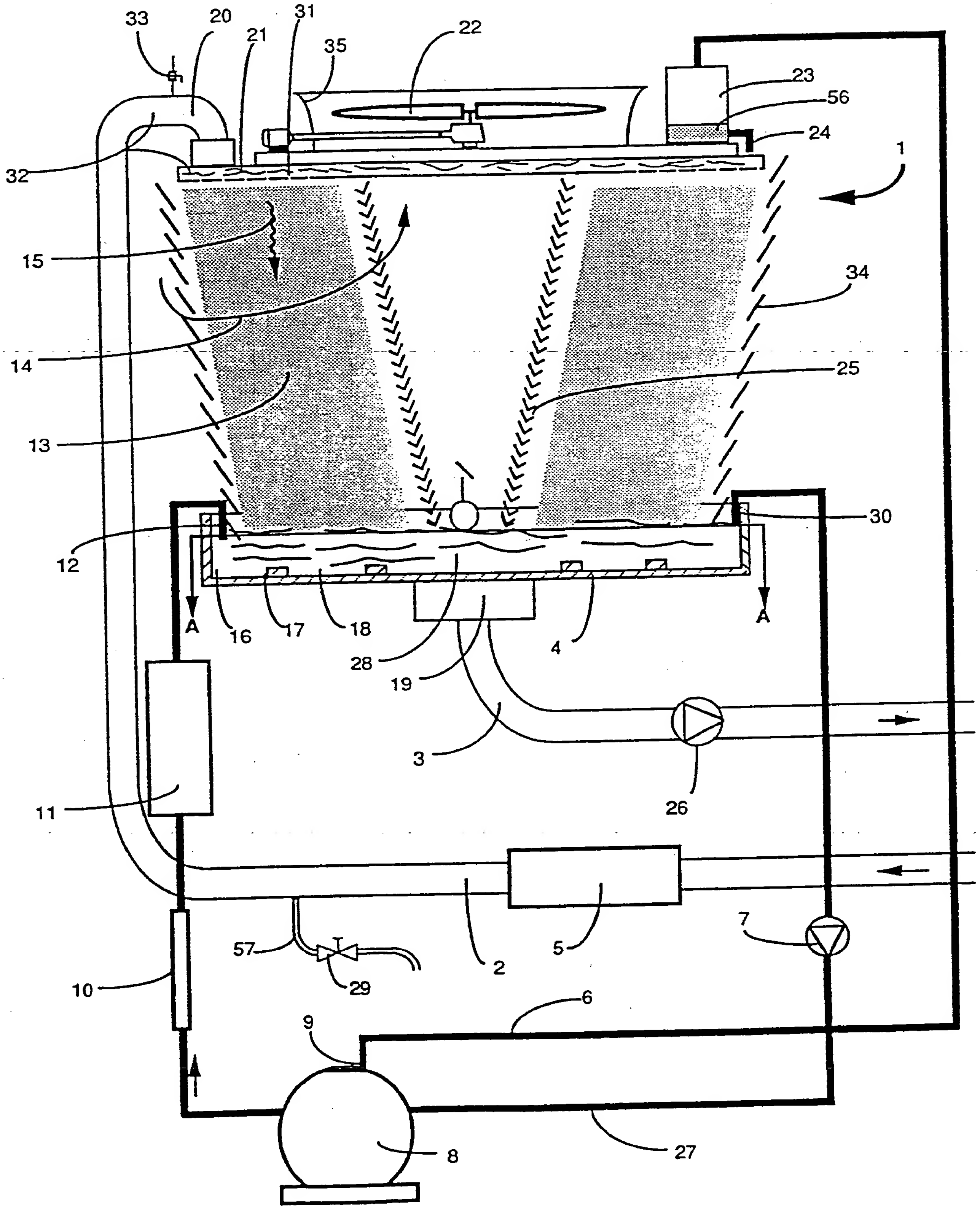
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Figure 1.

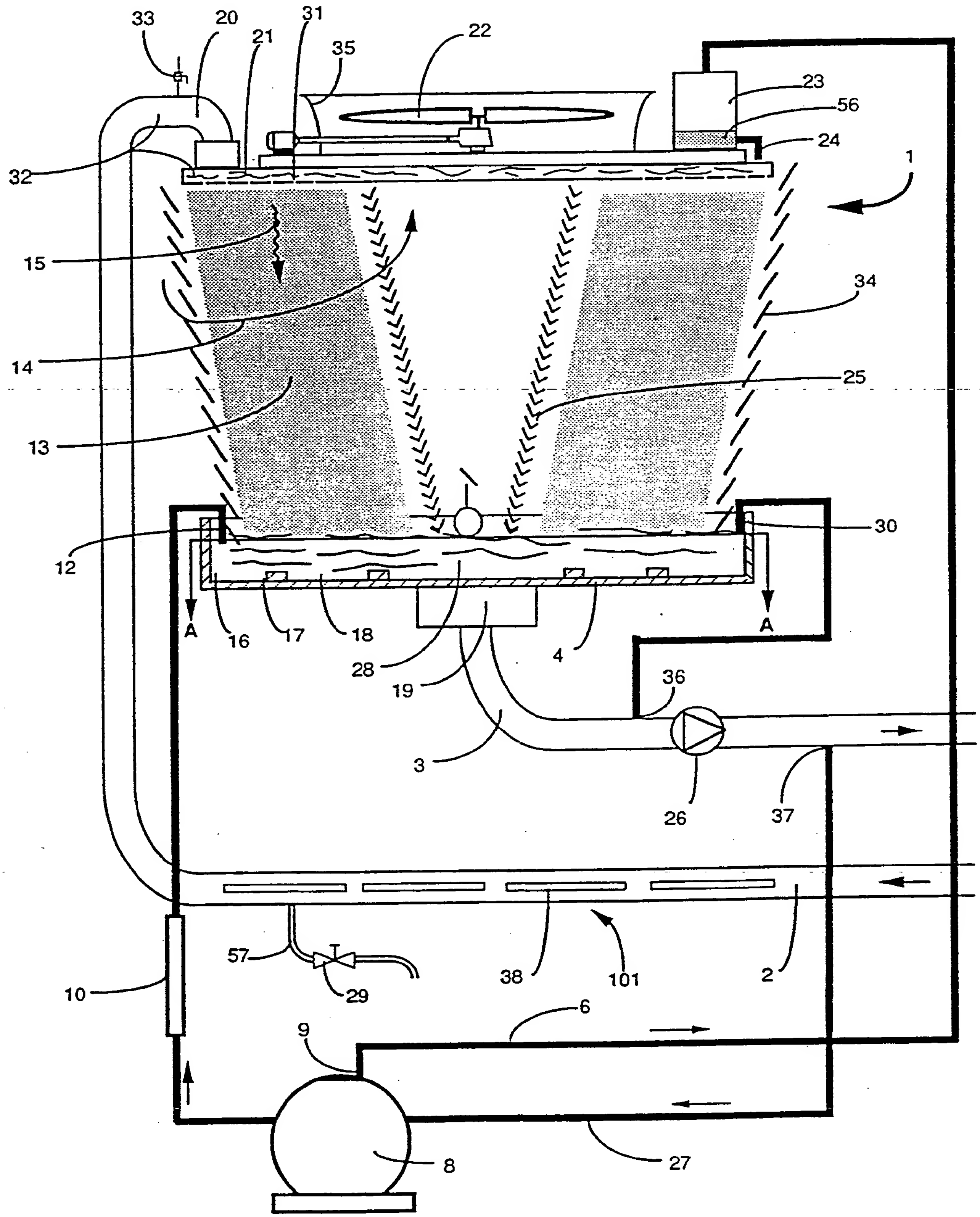
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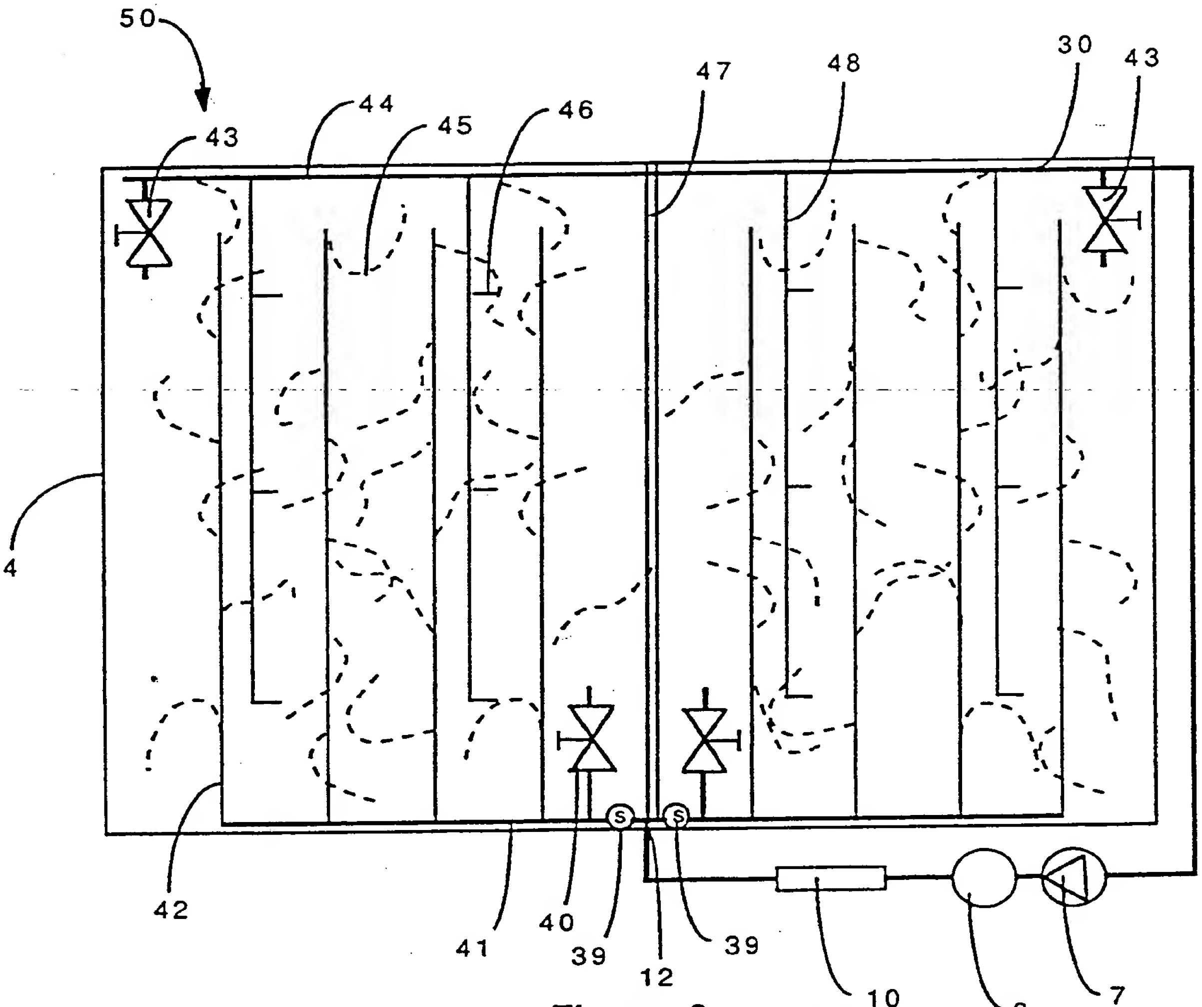
Figure 2.



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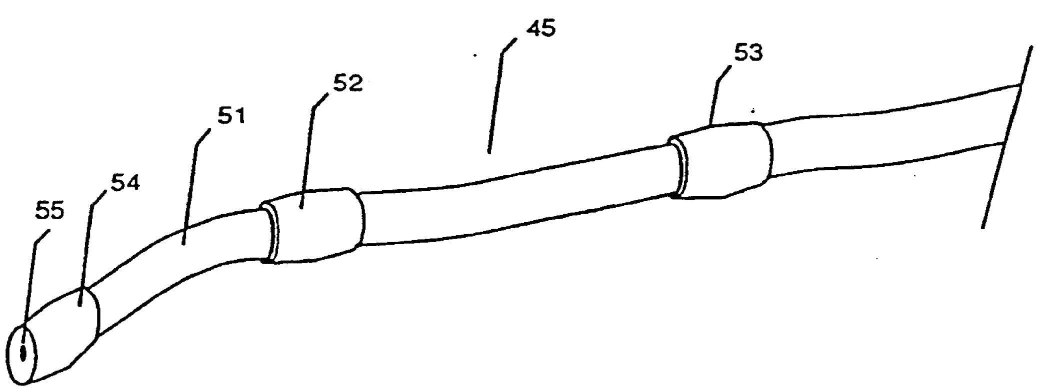

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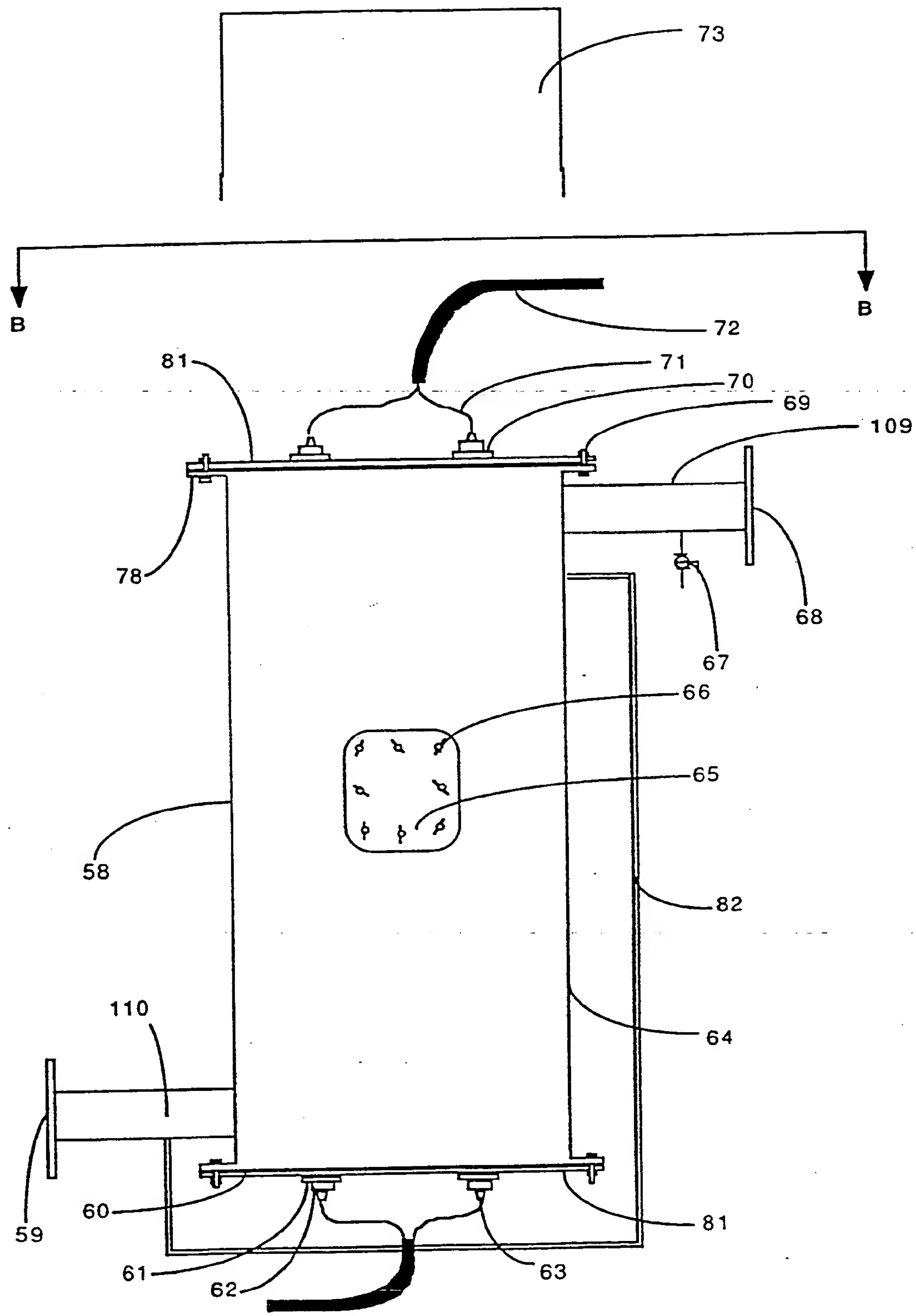

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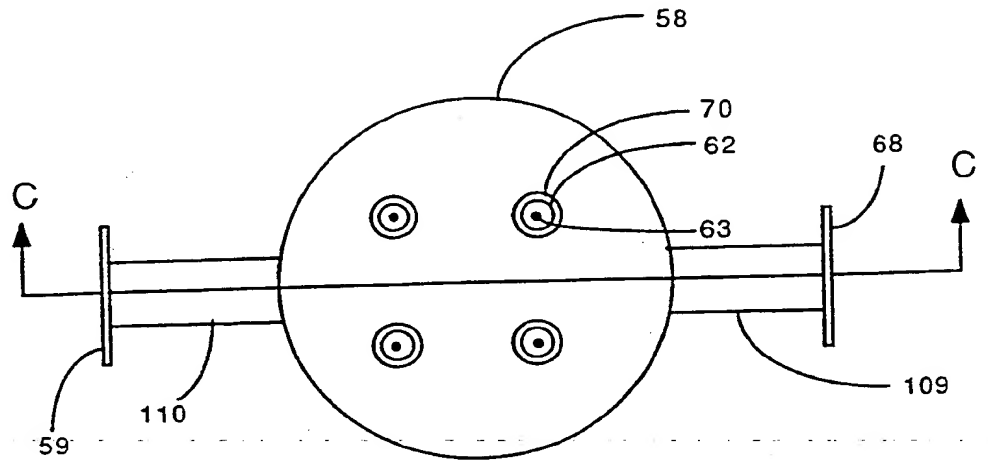

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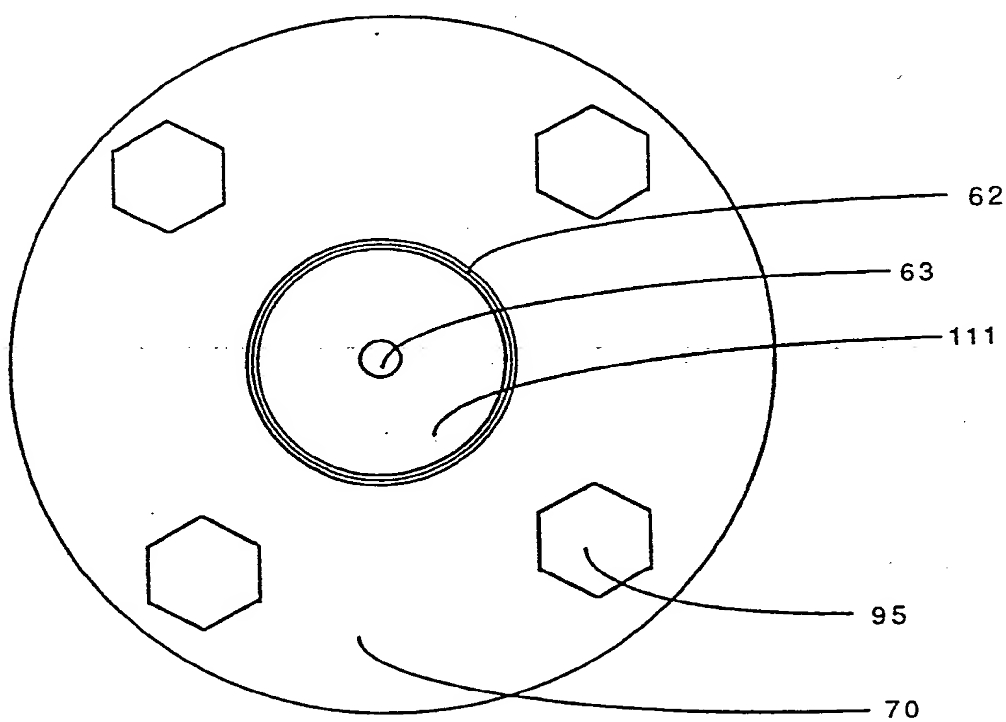

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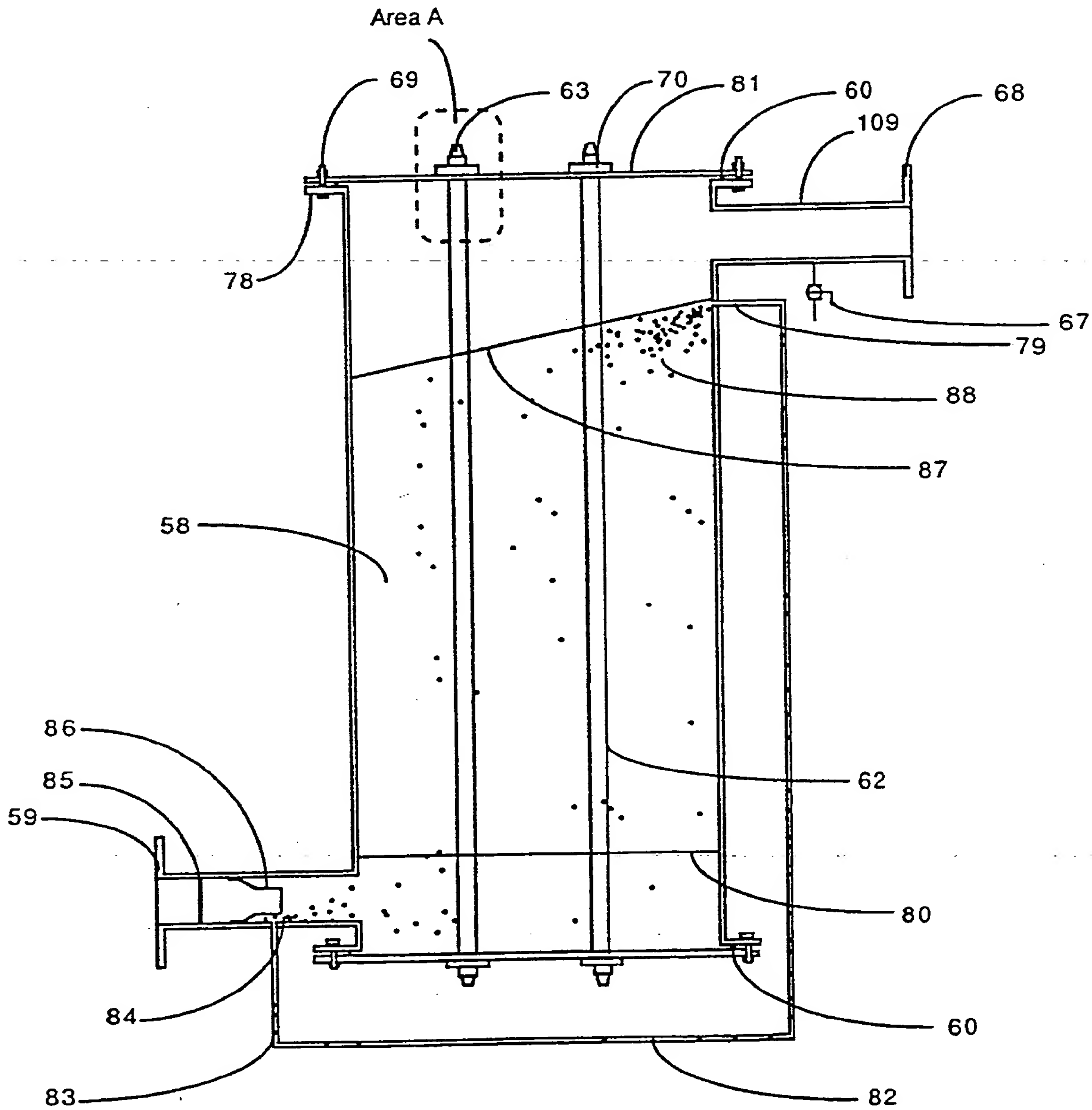
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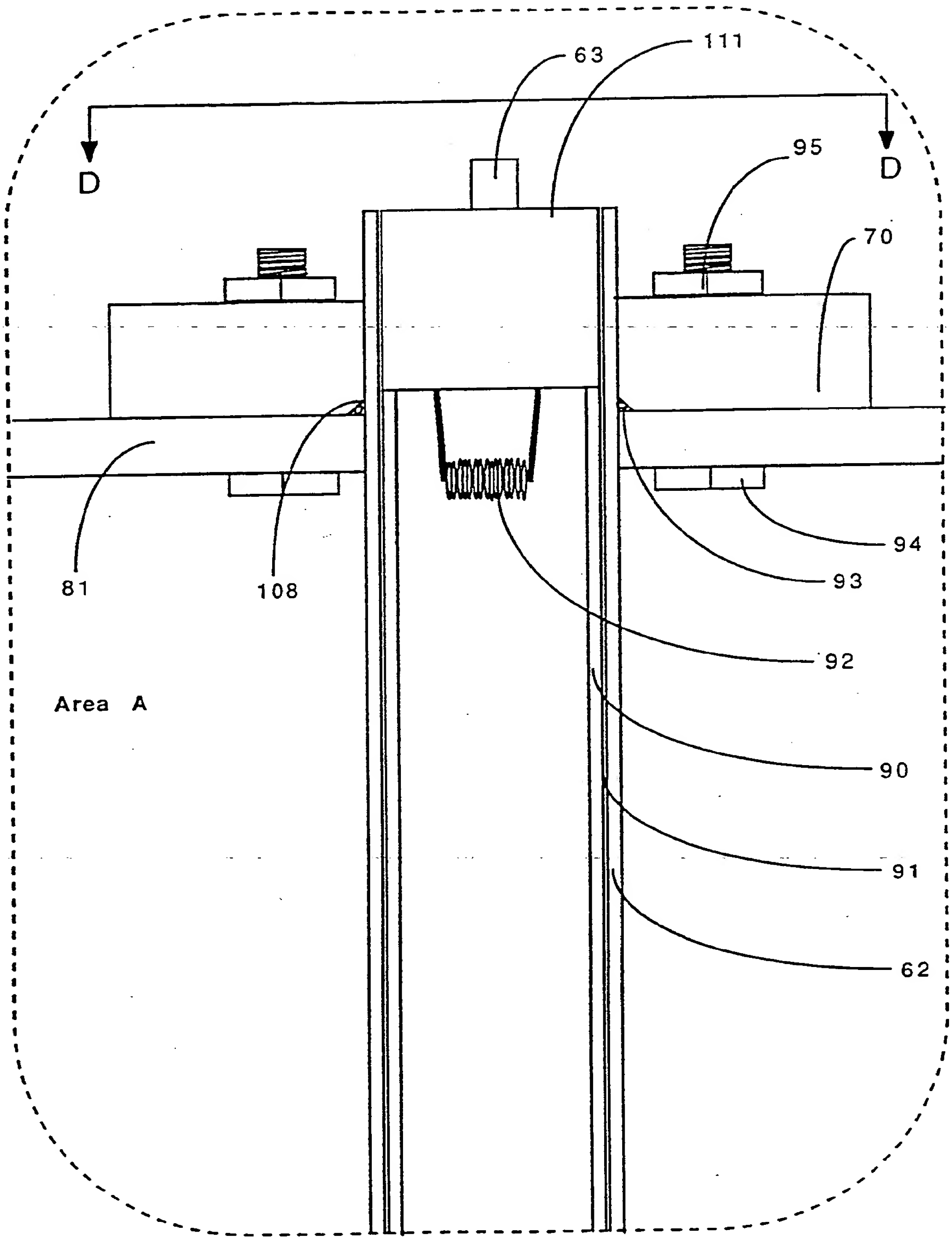
Figure 8.



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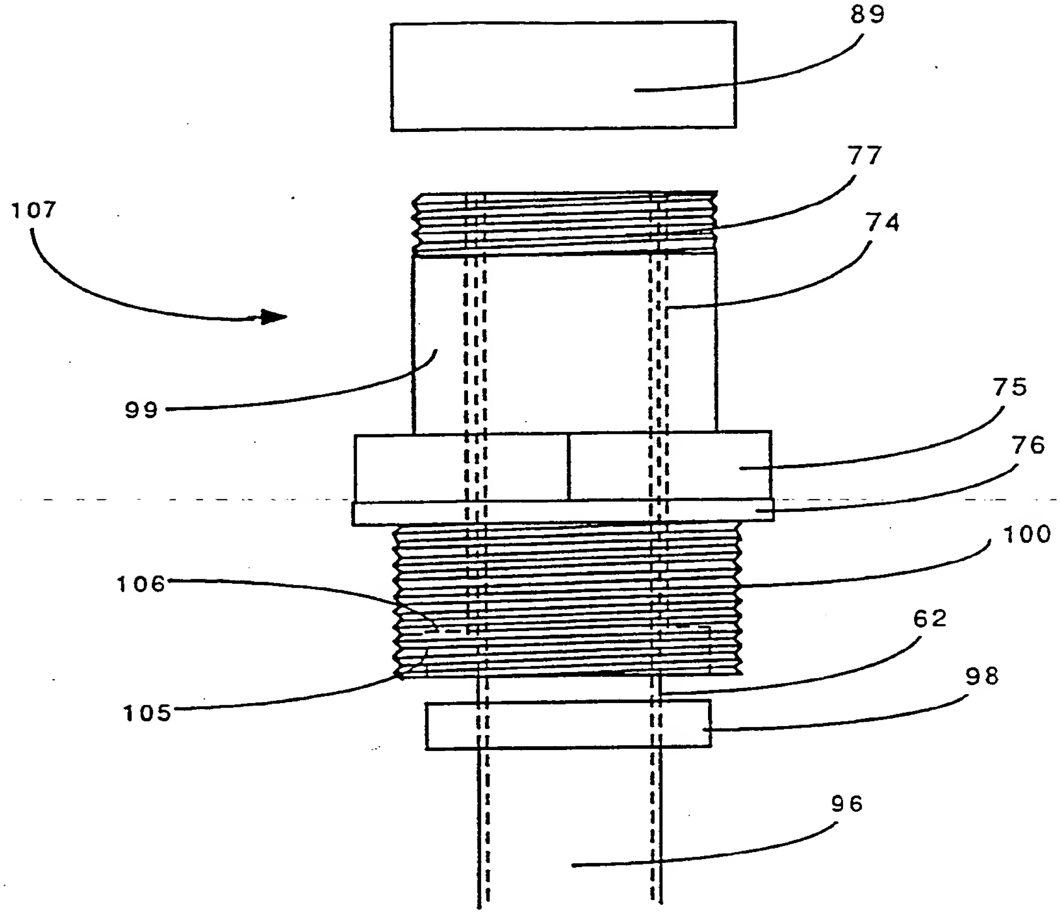

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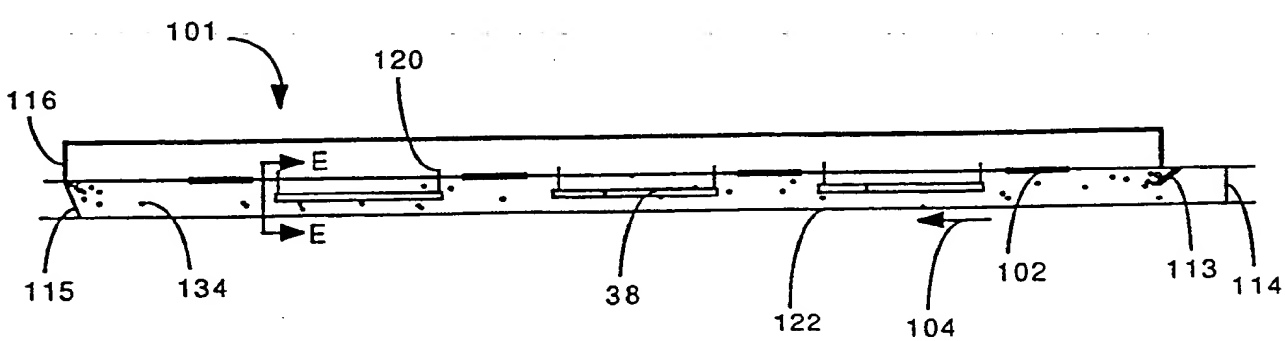

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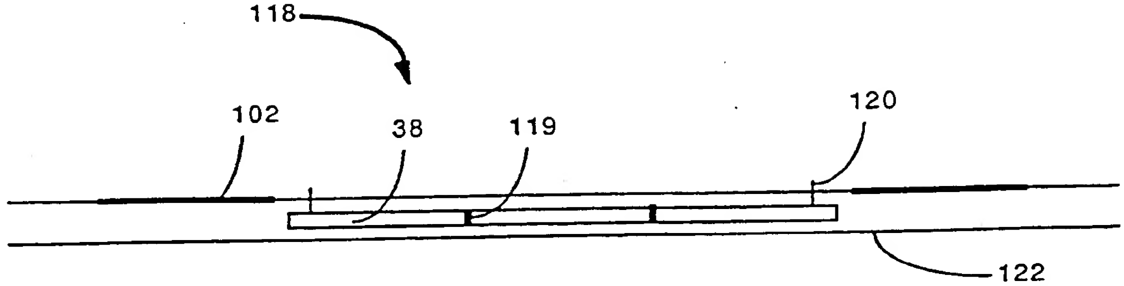

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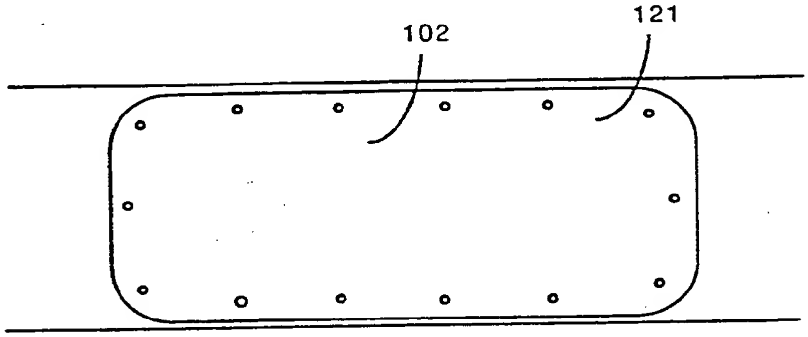

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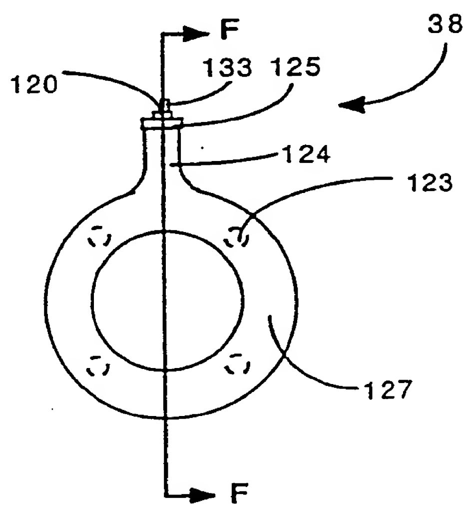

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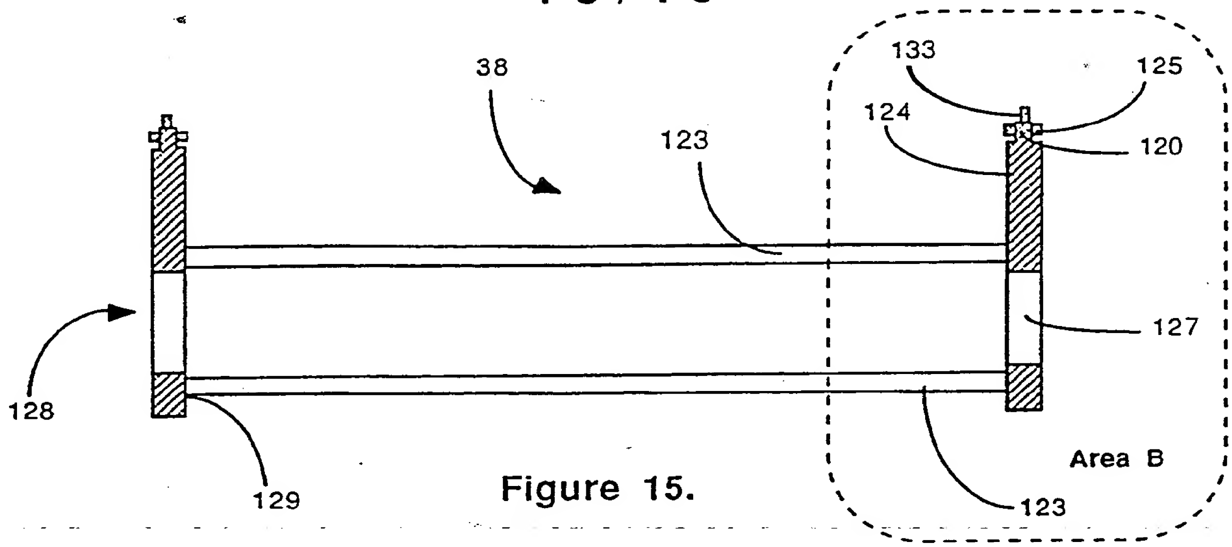

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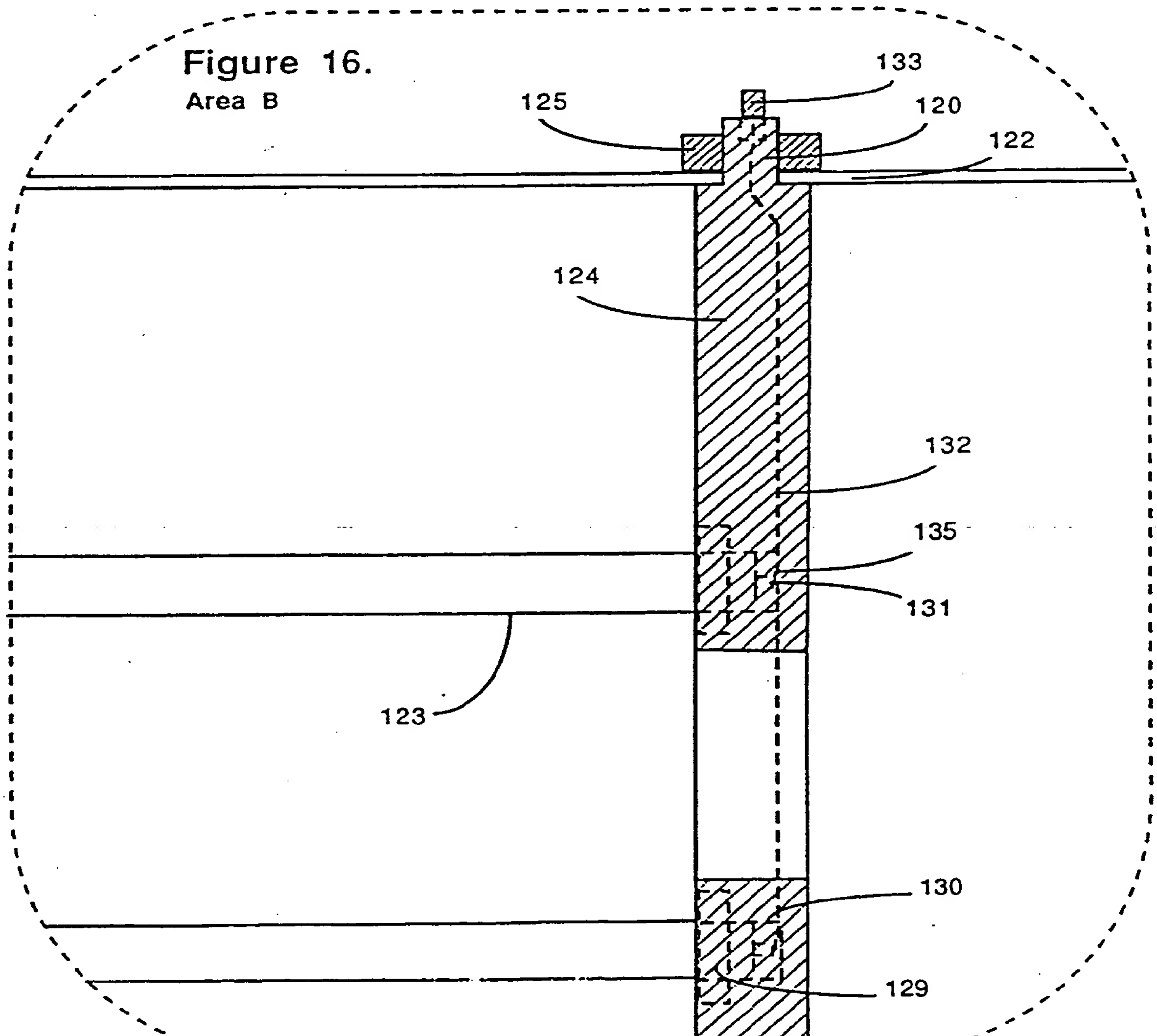

Figure 16.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 90/00420

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.^{5} C02F 1/32, 1/34

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	C02F 1/32, 1/34

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
Y	AU,A, 17668/88 (FUKUDA et al) 3 March 1989 (03.03.89) See entire document	(1-3,9-10,14-15)
Y,P	US,A, 4906387 (PISANI) 6 March 1990 (06.03.90) See entire document	(1-3,9-10,14-15)
X,Y	Derwent Abstract Accession no. 85.156262/26, JP,A, 60-087889 (ALVAC SERVICE KK) 17 May 1985 (17.05.85)	(15)
X,Y	FR,A, 2383886 (LEBLON) 13 October 1978 (13.10.78) See entire document	(15)
A	GB,A, 1545595 (STAUSBERG et al) 10 May 1979 (10.05.79)	

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
18 December 1990 (18.12.90)	24 December 1990
International Searching Authority	**Signature of Authorized Officer**
Australian Patent Office	R.W. Allan R.W. ALLAN

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON
INTERNATIONAL APPLICATION NO. PCT/AU 90/00420

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members					
AU 17668/88	JP	1194990	US	4959142		
GB 1545595	AT	6087/76	BE	846622	CH	618147
	DE	2543418	DK	4355/76	FR	2325607
	NL	7609896	SE	7610709		

END OF ANNEX